Gravity Lesson Plans

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Eighth Grade Integrated Science

Standard IV: Students will understand the relationships among energy, force, and motion.

Objective 2: Examine the forces exerted on objects by gravity.

- a. Distinguish between mass and weight.
- b. Cite examples of how Earth's gravitational force on an object depends upon the mass of the object.

Intended Learning Outcomes (ILOs)

- 1. Use Science Process and Thinking Skills
 - a. Observe objects for patterns and record both qualitative and quantitative information.
 - e. When given a problem, plan and conduct experiments in which they
 - Plan procedures to control independent variable
 - Analyze data and construct reasonable conclusions
- 4. Communicate Effectively Using Science Language and Reasoning.
 - a. Provide relevant data to support their inferences and conclusions.
 - b. Use mathematical reasoning to communicate information.

Time Needed to Complete Inquiry: 3 days

Inquiry: What is the relationship between the mass of an object and the gravitational force it exerts? (Confirmation) What is the relationship between distance and the force of gravity? (Structured Inquiry) What is the best way to construct a beam that will support the greatest load? (Guided Inquiry)

Prior Knowledge Needed: Students should be aware of the difference between a spring scale and a balance.

Materials/ Resources Needed for the Investigations:

What's Pulling On Me? Activity:

- Printed worksheets
- Calculators

Paper Beam Activity:

- 10 sheets 8 ½ X 11 paper for each student or group
- 1 meter masking tape for each student or group
- 2 tables or desks
- weights and device to hang below or on the constructed beams

Procedures of the Investigation:

What's Pulling On Me:

- Hand out the worksheets and calculators and have the students calculate the
 desired information for the data tables. They should then evaluate the information and make
 conclusions based on the data.
- 2. After the students have completed the first worksheet, discuss the calculations they have made and make certain they understand what mass and weight are. They should also understand that the mass of objects remains constant, but weight will change and depends on the mass of the object exerting a force on them.

Also after completing the first worksheet, discuss with the students that they used data to infer (in this case, extrapolate) that their body (and anything with mass) also contains and exerts a gravitational force.

3. For the second worksheet, have the students work in small groups to develop their data table, graph, and interpretation. Have the groups present their data table, graph and interpretation to the rest of the class. As a class discuss the merits of the different data tables, graphs, and interpretations. Using formative assessment techniques, help guide students to the consensus that gravitational force decreases with distance.

Sample Data Table for Janet's Experiment

Location	Distance from the	Janet's Weight	Janet's Mass
	center of the Earth		
Sea Level	6378 km	489.91 N	50 kg
Salt Lake City	6379 km	489.69 N	50 kg
Top of Everest	6387 km	488.56 N	50 kg
In a jetliner	6389 km	488.28 N	50 kg

Paper Beam:

Project Description: This project can be done individually, in pairs, or in groups. The object is for the students to construct a beam made only of paper and tape. The beam should be 72 cm long. Weight will be hung from the beam to see how it will hold before breaking. Before construction of the bridge, students should experiment with the strength of various shapes- circles, triangles, squares.

Explain to the students that you will be placing two desks so that they are 50 cm apart. The beam will span this opening and objects (weights) can be hung on the beam until it breaks. I use a weight hanger suspended from the beam and put weights on the hanger until the beam breaks. Then have the students construct the beam using 10 sheets of $8\frac{1}{2}$ " x 11" paper and 1 meter of masking tape. Once the beams are built, begin testing the strength of them.

Data Analysis: As the beams are brought up and placed on the table, students explain how the beam was constructed. As the testing proceeds they look for the areas where the beam is showing stress and where they would reinforce the beam.

You should discuss the affect gravity is having on the beam and how beams and bridges are constructed to overcome the effects of gravity.

Once all the beams have been tested, have the students construct another beam with the knowledge they have gained and then test the 2^{nd} beams.

Assessment: Teachers should be constantly using formative assessment to judge the students understanding. An excellent time is when the students present their data tables and interpretations during the second part of "What's Pulling On Me?"

What's Pulling On Me? – Part 1

Gravity, gravity, what is gravity? Ever drop something? What happened to it? It's safe to say that if you were standing on the Earth, it fell toward the Earth. But, does only the Earth have gravity? No, we know the sun has gravity. That's what keeps the Earth in orbit around it. What about the other planets? Do they have gravity? Do only stars and planets have gravity? What causes it? How does it work?

The Law of Universal Gravitation (gravity) was developed by Sir Isaac Newton. He had some of the same questions as you. Did an apple fall and hit him on the head – No! But his family did own orchards and I'm sure he had seen apples fall as he walked through the garden. When asked how he made his great discoveries, he said "I keep the subject constantly before me, till the first drawings open slowly, and little by little, into the full and clear light."

The result of Newton's thoughts and calculations is the mathematical equation that can be used to accurately describe the effects of gravity – The Universal Law of Gravitation. No one, not even Newton, has been able to explain what causes gravity. For now, we can only explain what gravity does and what affects it.

Ever wonder what you would weigh on the moon, the sun, or other planets? Let's find out. First of all, weight is a measurement of the force of gravity pulling on an object's mass. But just what is mass? Mass is a measurement of how much matter is in an object. Matter is just the bunch of atoms or molecules (tiny particles) packed into the space an object takes up (its volume). The more matter an object has, the greater its mass. To find your mass, take your weight in pounds and divide it by 2.2 (there are 2.2 pounds in a kilogram). This will give you your mass in kilograms.

The force of gravity on the surface of the moon, sun, and some of the planets has been calculated for you in the data table below. The mass of them is also shown. To find your weight in pounds in that location, just multiply your weight in pounds on Earth by the gravitational force for that location. Calculate your weight for each location shown and fill in the table.

(Weight on Earth) (Gravitational force on surface) = Your weight in that location

Name	Mass (X 10 ²⁴ kg)	Gravitational force on the surface	Your weight on that location (lbs)
Earth	5.98	1.0	
Mars	0.64	0.4	
Jupiter	1900	2.4	
Pluto (dwarf planet)	0.0013	0.1	
Moon	0.07	0.2	
Sun	1,989,000	27.1	

Now you know approximately how much you weigh in various locations in the solar system. Before answering the questions on the next page, review the definitions of matter and mass above.

1.	Does your weight change if you were to travel to Jupiter?
2.	If you traveled to Jupiter, would the amount of matter in your body change? Why or why not?
3.	Would your mass change if you went to Jupiter? Why or why not? What would be your mass on Jupiter?
4.	After looking at the table above, what conclusion can you make about what affects the force of gravity (your weight) when you travel to different planets? Precisely explain any relationship you see.
5.	Based on your analysis in #4 above, do you think (infer) that your body also contains and exerts a gravitational force? Explain why or why not.

What's Pulling On Me? – Part 2 The Tales of Janet the Globe-Trotter

Janet lives in San Francisco (which is 6,378 km from the center of the Earth). Using a spring scale she discovered her weight was 489.91 N. She was able to find a large balance. Janet discovered that when a 50 kg mass was placed on one side of the balance, and she climbed on the other side, it was in perfect balance.

Janet traveled to Salt Lake City (which is 6,380 km from the center of the Earth) to visit her grandmother. While there she decided to do the same experiment she had done at home. Using the same spring scale again, she discovered that she weighed 489.69 N. Once again she found a large balance and when she climbed on it a 50 kg of mass was placed on the other side and it balanced.

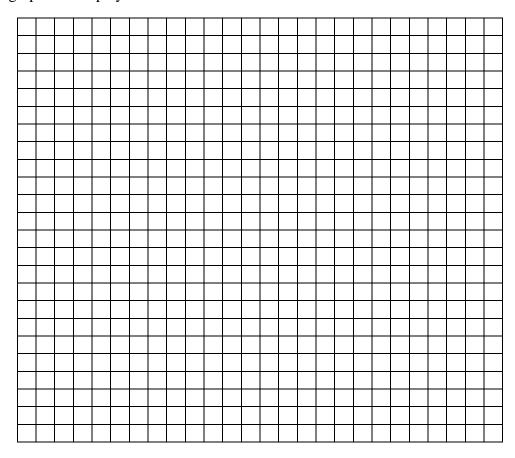
Janet had a friend in Nepal that she spent the summer with. Mt. Everest is in Nepal and is 6,387 km from the center of the Earth. After much huffing and puffing, Janet and her friend climbed to the top of Mt. Everest. Once again she decided to repeat her experiment and discovered that on the spring scale on the top of Mt. Everest she weighed 488.56 N. She and her friend made a "teeter-totter" balance and discovered that once again a 50 kg mass on the other side would let her balance.

In the jetliner on the way home, she decided to try her experiment once again. The plane was 6,389 km from the center of the Earth. Janet talked with the flight attendant and she was able to find a balance for Janet to use. Using the spring scale, Janet found her weight to be 488.28 N. A 50 kg mass placed on the balance on the side opposite her was able to balance the scale.

Janet took all the information she had gathered from her experimentation and put it into a data table to see what she had learned.

- 1. Besides the change of location (e.g., Salt Lake City), what was the manipulated (independent) variable in Janet's experiment?
- 2. What was the responding (dependent) variable in Janet's experiment?
- 3. What things did Janet have to keep constant to make her experiment accurate?
- 4. Create a data table that displays all the information Janet collected during her experiment.

5. Create a graph that displays the information Janet collected.



- 6. What conclusion can you make about what affects the force of gravity from the information Janet gathered?
- 7. Predict what would happen to your weight if you were in a spaceship hovering 100 km above the surface of the Earth.
- 8. Predict what would happen to your weight if you were 100 km below the surface of the Earth.
- 9. Based on your understanding of how a balance works, predict what the mass readings would be if Janet were 100 km above the surface of the Earth and 100 km below its surface.